Simplified convective heat transfer in vertical airflow regimes with shading device

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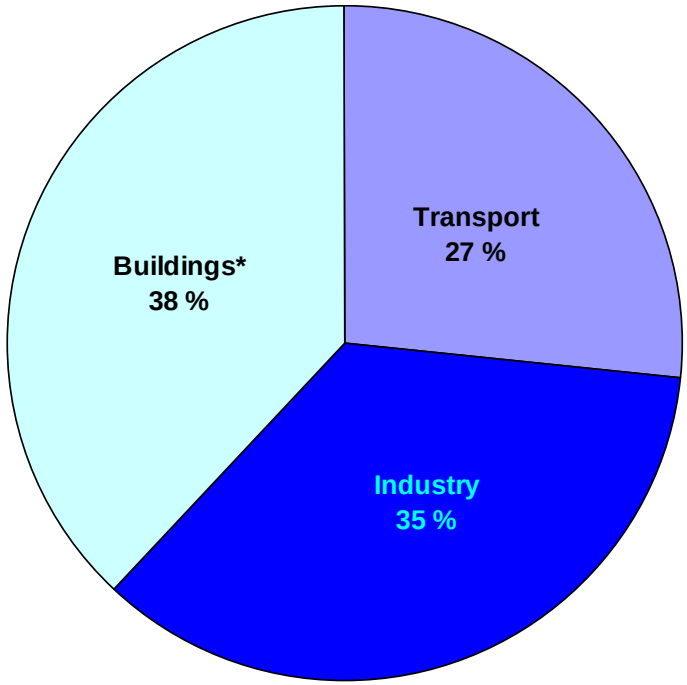
Introduction

- Need for sustainable development
- Key role of Building industry

Image credits: IEA, 2006

Energy consumption (Norway)



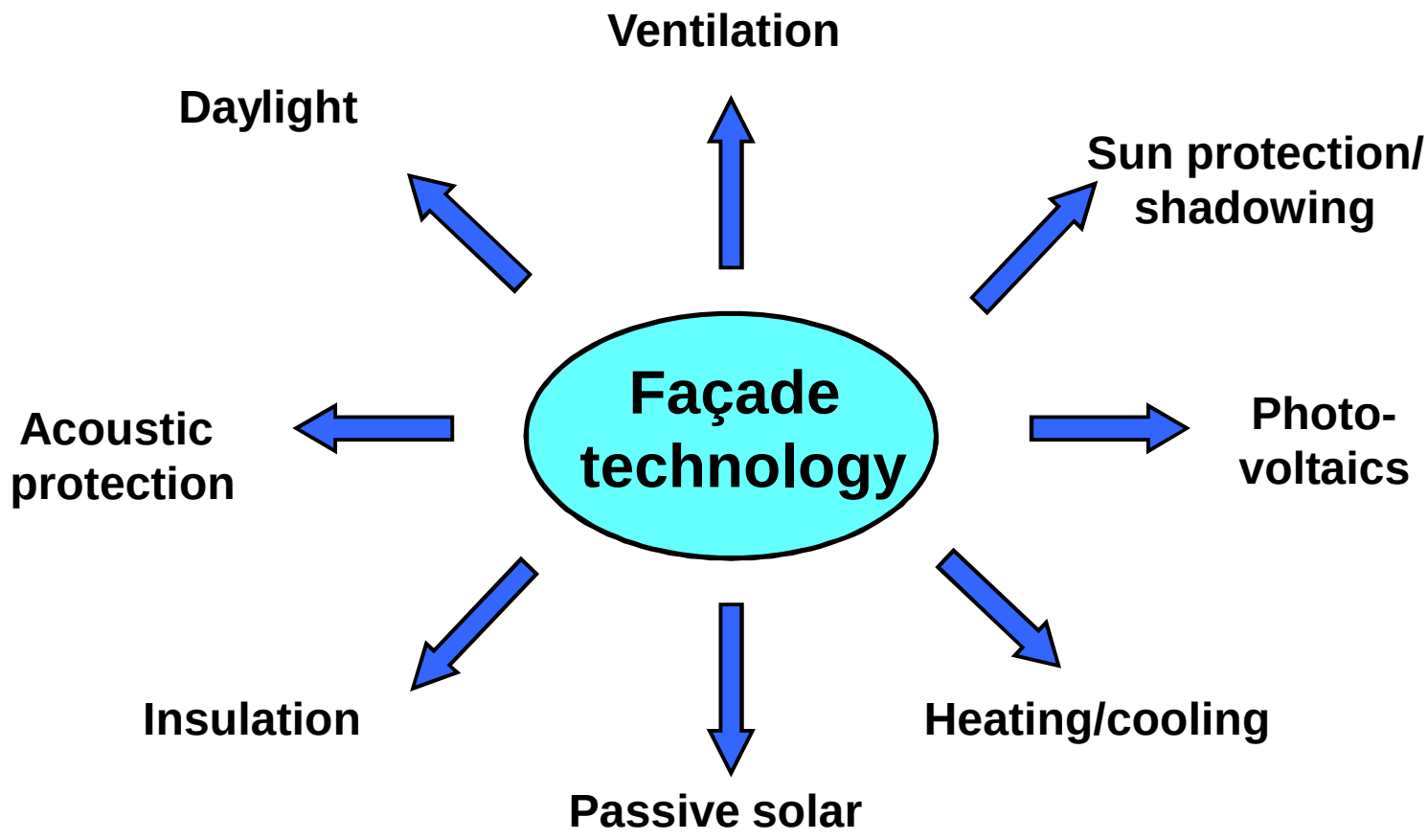
Introduction

- New concepts for sustainable buildings
- Double-skin facades for office buildings

left: Multimedia Center, Hamburg, Germany by Foster and Partners right: Uni, Erlangen, Germany by UBA Erlangen
Image credit: http://www.fosterandpartners.com

Introduction

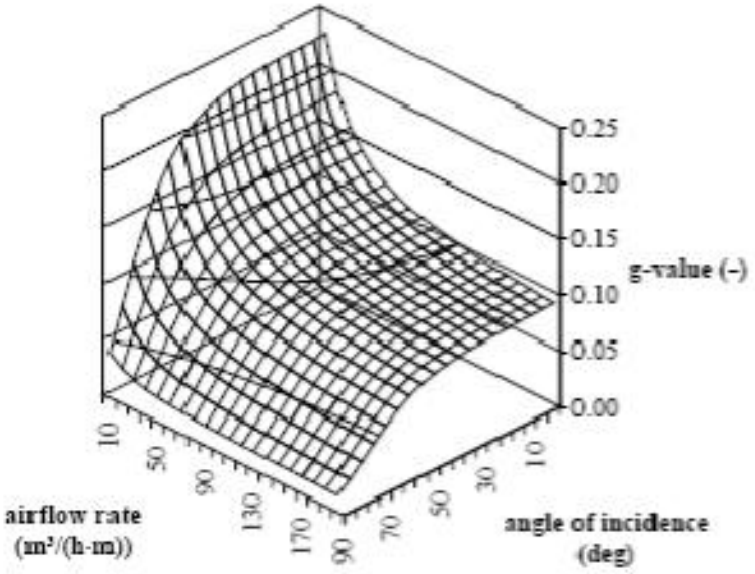
- The facade as an integrating building system



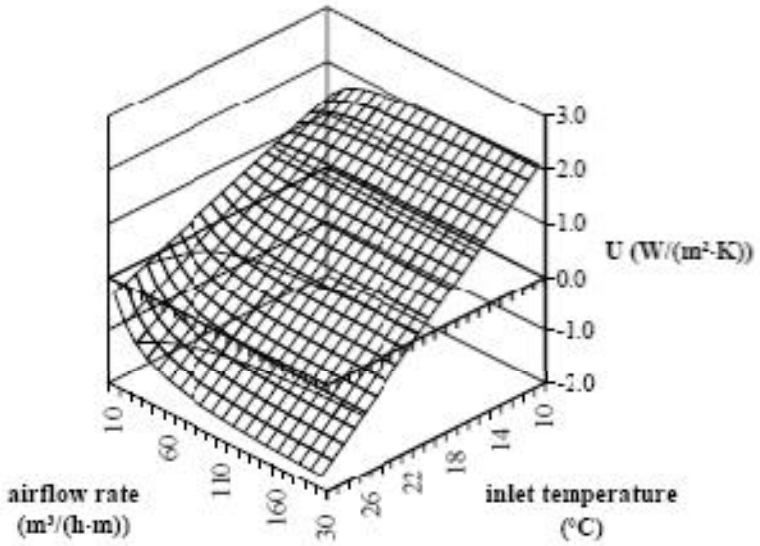
Double-skin facades (DSF)

- Dynamic performance

- g-value



U-value



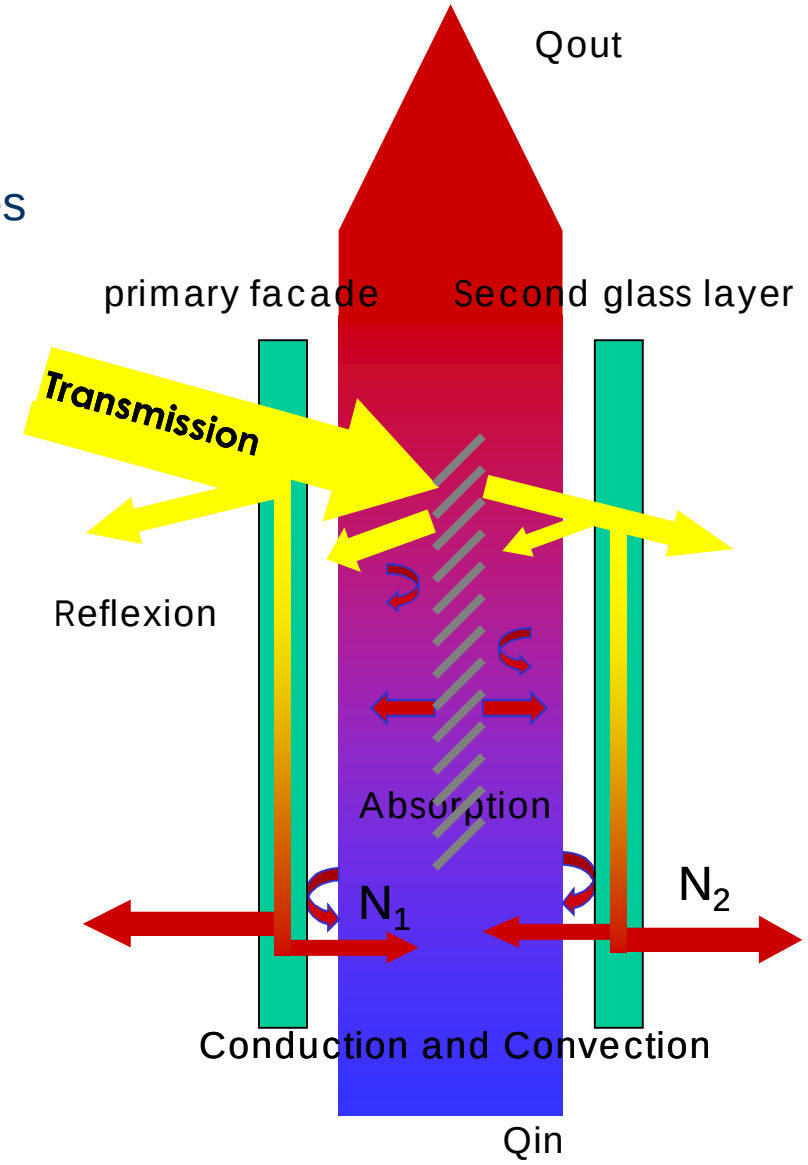
Saelens, D. (2002). "Energy performance assessment of single storey multiple-skin facades," PhD thesis, KATHOLIEKE UNIVERSITEIT LEUVEN, Leuven.

Objectives

- Performance evaluation of buildings with DSF
- Radiation and conduction models were needed to describe the optical and thermal heat transfer mechanism in glass-glass configurations with vertical airflow regimes.
- Radiative, conductive, and convective heat transfer coefficients for the heat transfer through glass-glass configuration with internal obstructions were needed.
- Obstructions in the vertical airflow regime (i.e. shading device) with reflective and absorptive properties demand new heat transfer balance.

Methodology

- Convective heat transfer on vertical surfaces
- Internal shading device
- Distribution of solar radiation
- Transmission of radiation



Convective heat transfer coefficients

External vertical facade:

- hconv,o

Internal facade (cavity):

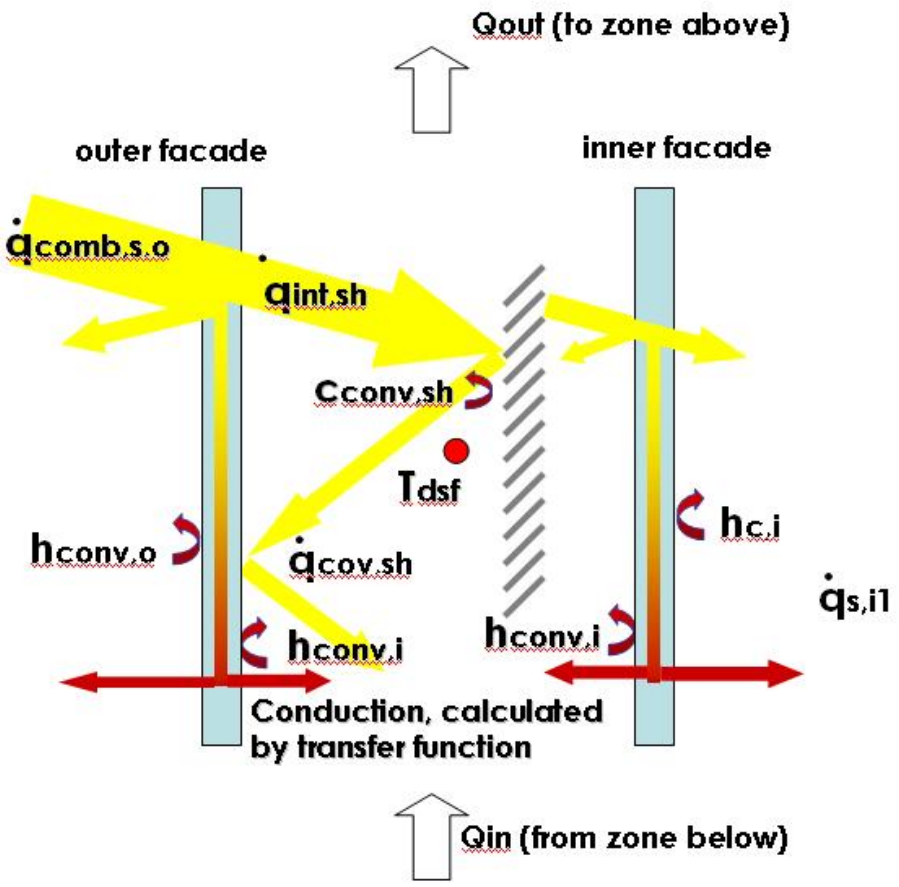
- hconv,i

Internal facade (room):

- hc,i

Internal shading device:

- Cconv,sh



Convective heat transfer coefficients

- $h_{conv,s,o}$ = 64 kJ/(hm^2 K) = 17,78 W/(m^{2}K) **(1)**
- For internal vertical surfaces

natural ventilated cavities: $h_{c,i} = 1.5 \times (T_{s,i} - T_{air})^{0.26}$ **(2)**

mechanical ventilated cavities: $h_{c,i} = 5.76 \times (T_{s,i} - T_{air})^{0.3}$ **(3)**

where

$h_{c,i}$ = convective heat transfer coefficient for internal vertical surface

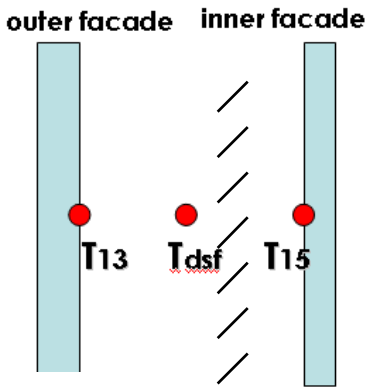
$T_{s,i}$ = internal surface temperature

T_{air} = air temperature of zone

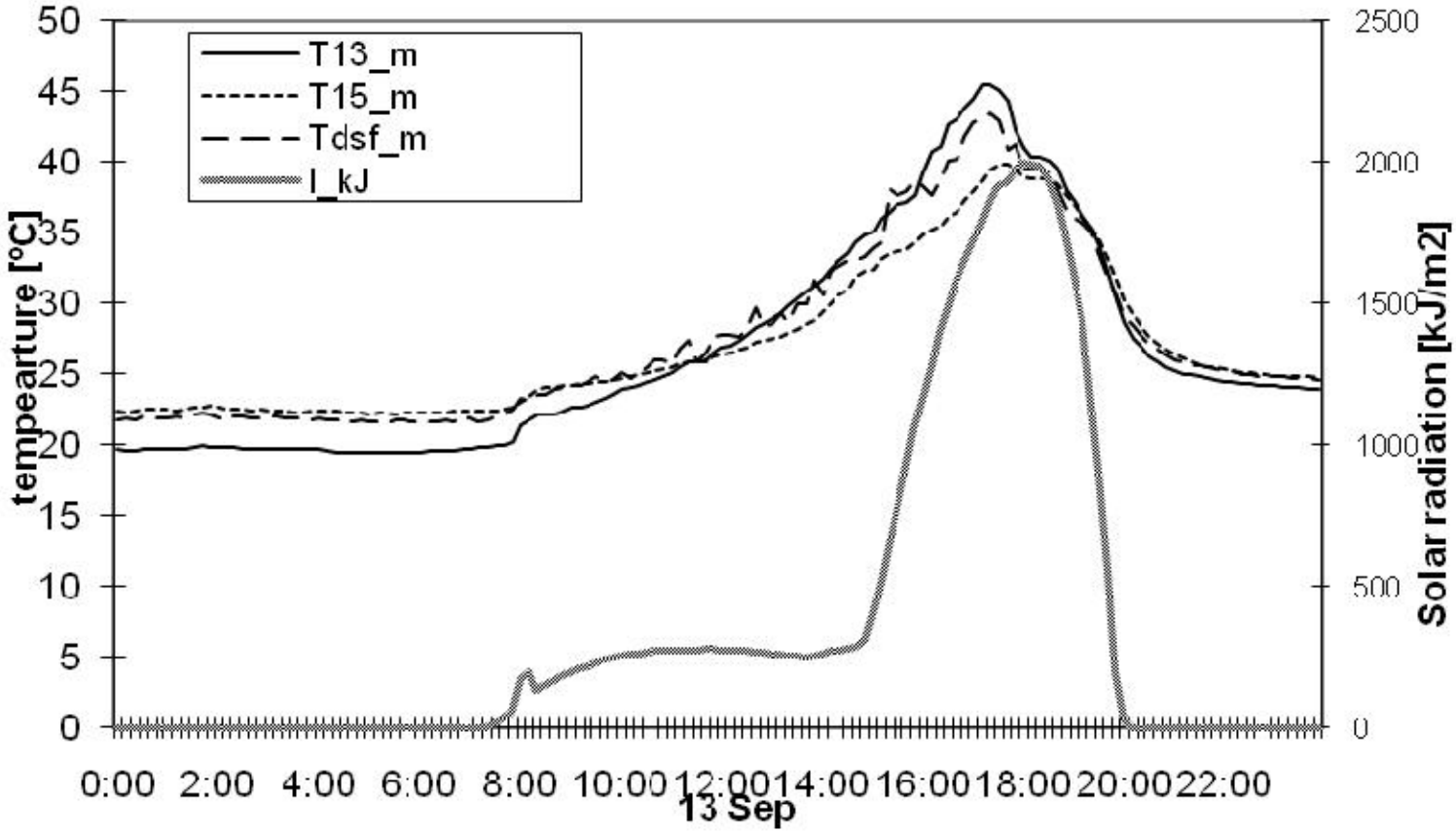
- For internal surfaces inside the room:

  $h_{c,i}$ = 11 kJ/(hm^{2}K) = 3,06 W/(m^{2}K) **(4)**

Results

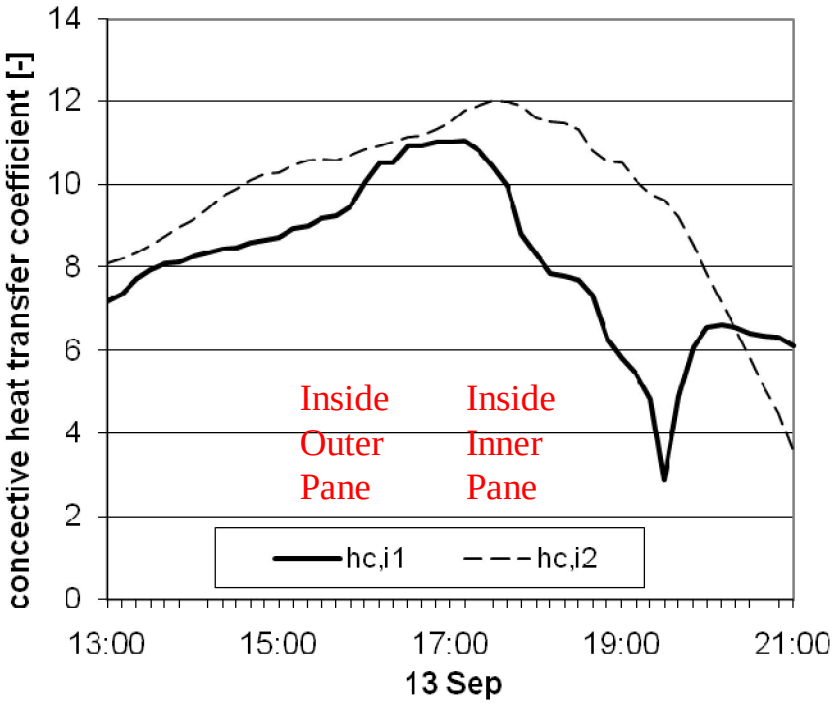


- Temperatures

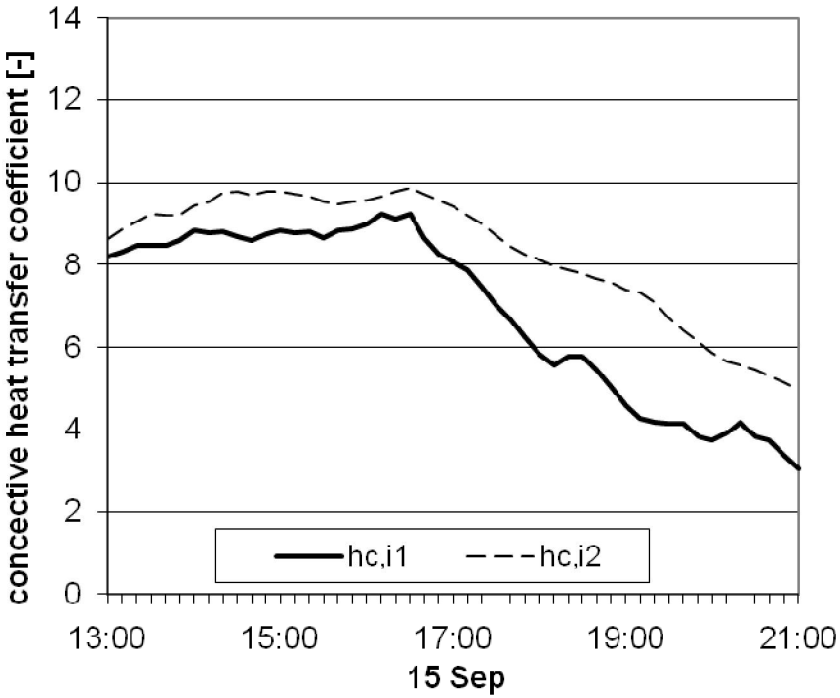


Results

- Convective heat transfer coefficients

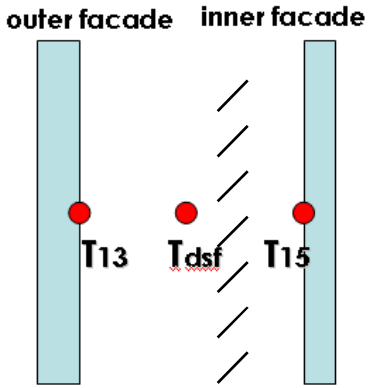


Sunny Day

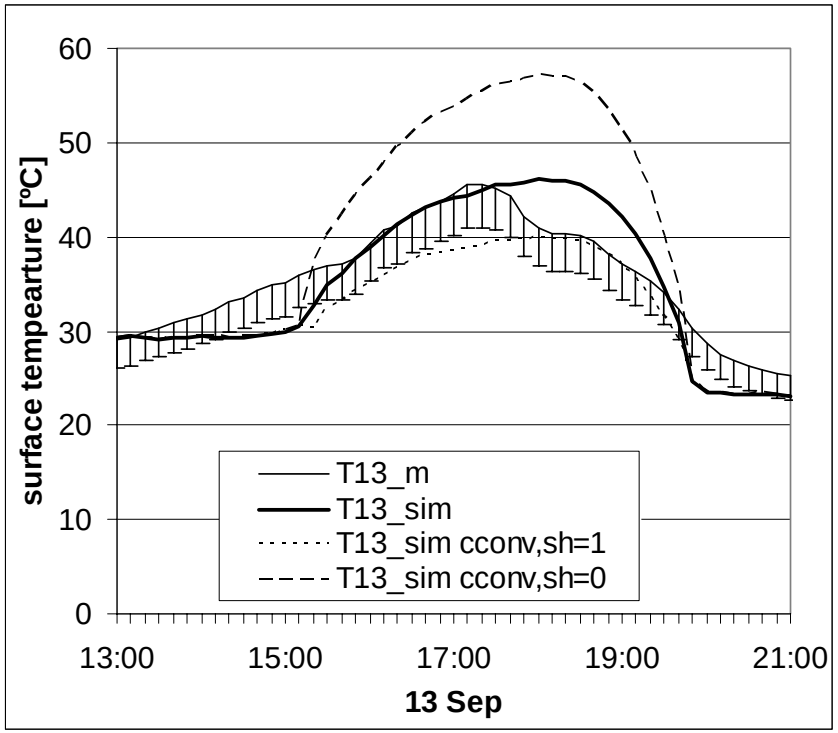


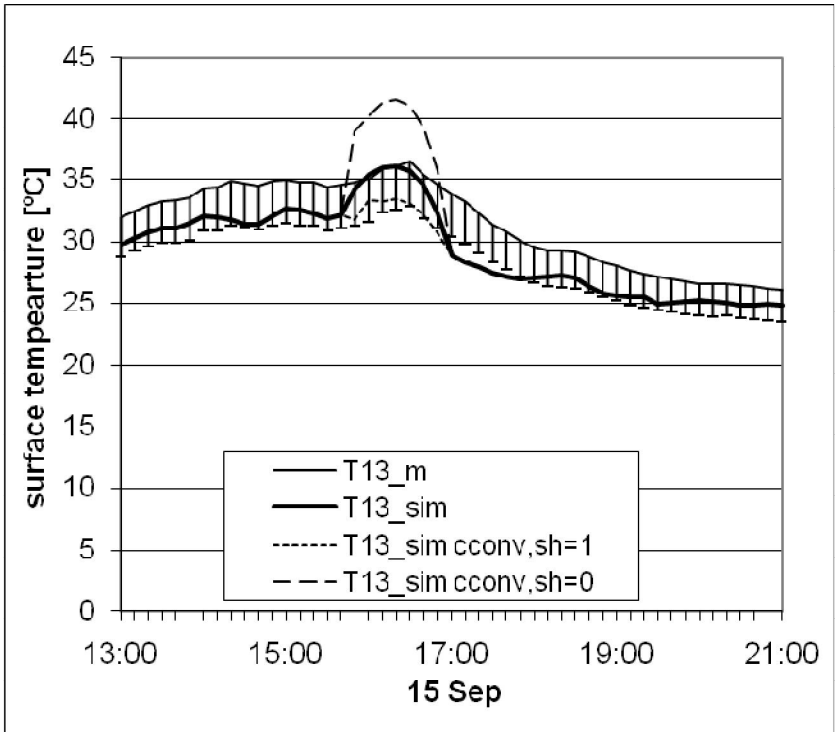
Party Cloudy Day

Results



- T13

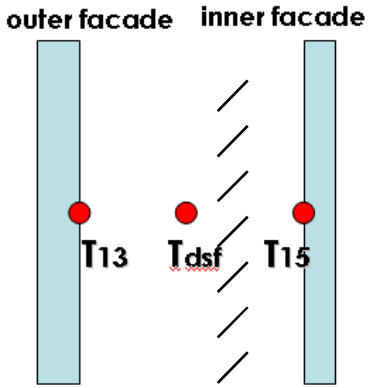




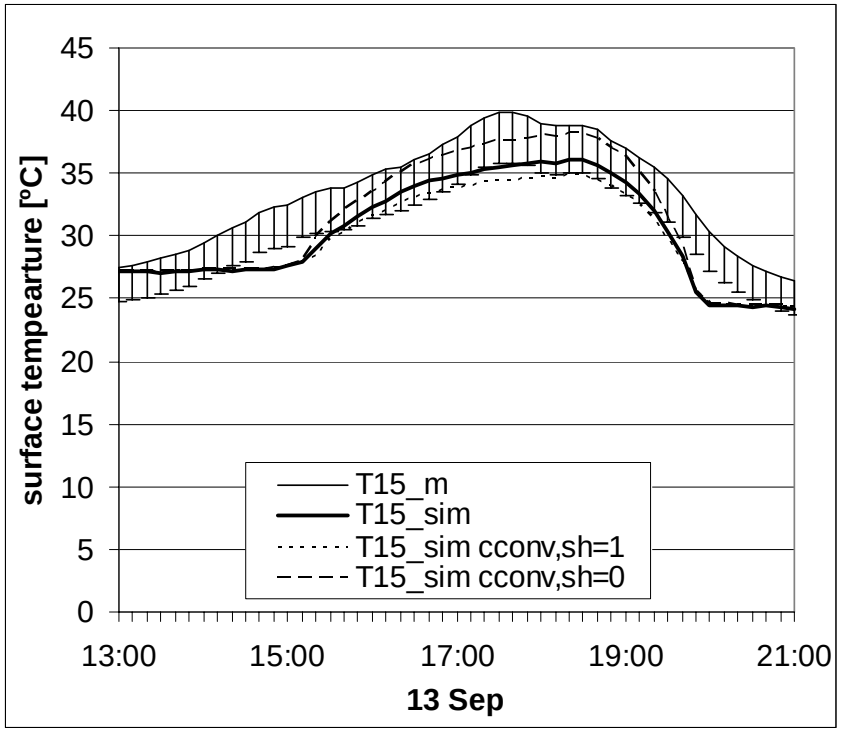
Sunny Day

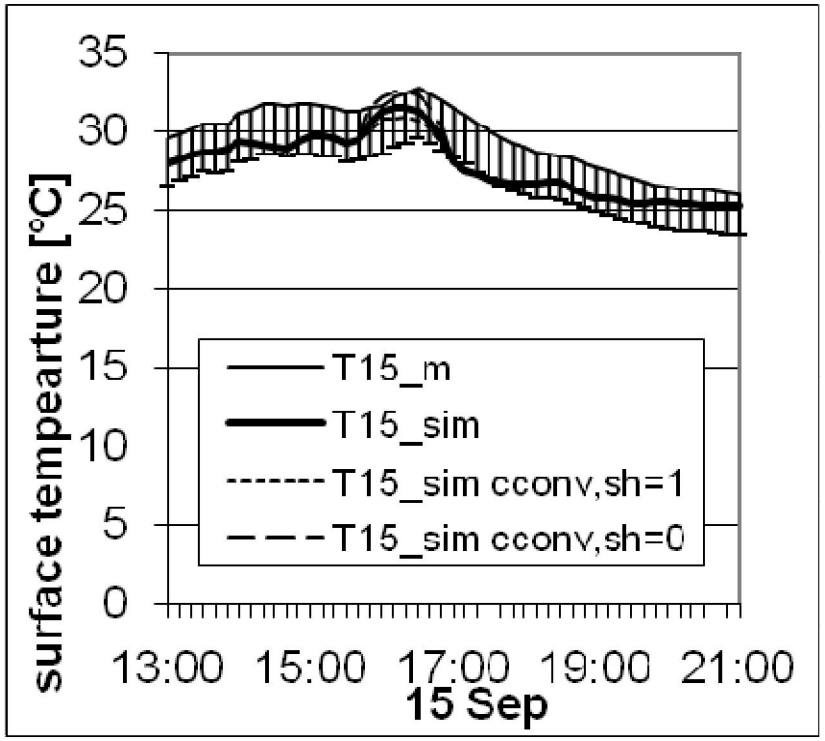
Party Cloudy Day

Results



- T15

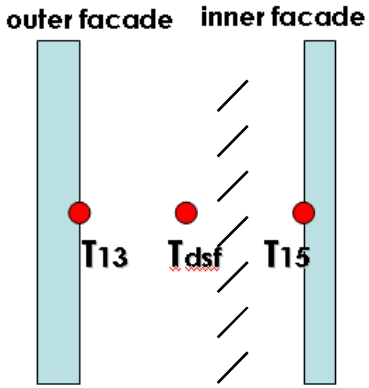




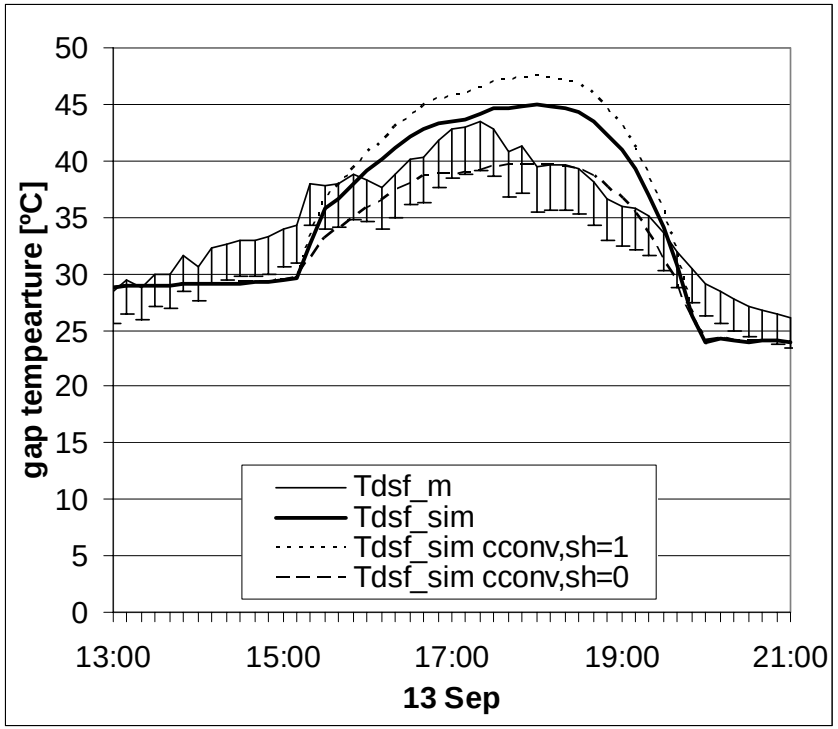
Sunny Day

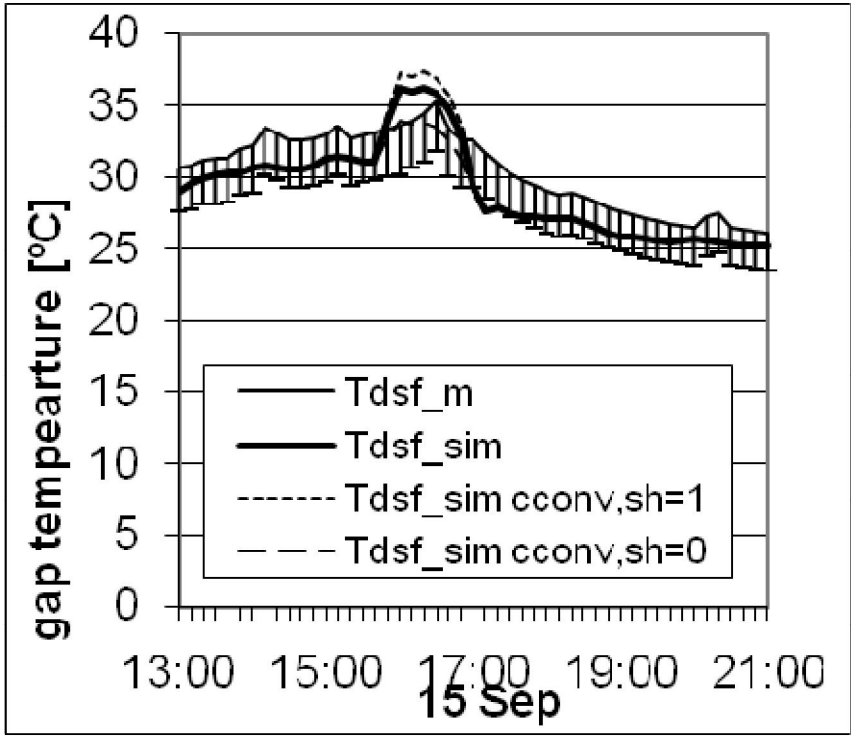
Party Cloudy Day

Results



- Tdsf





Sunny Day

Party Cloudy Day

Conclusions

- Obstructions in the vertical airflow regime (i.e. shading device) with reflective and absorptive properties demand the set-up of a new heat transfer balance.
- In order to describe the optical and thermal heat transfer mechanism in glass-glass configurations with vertical airflow regimes radiation and conduction models were developed.
- The simulation results were validated with measured data of air temperature regimes and different solar radiation in an existing ventilated double façade.
- The comparison show very good agreement. However, it must be realized that the "evidence" is based on a rather limited number of experimental data and comparisons.
- Thus, more research and an increase in number of experimental data is needed in order to get a better confidence in using the model for further energy analysis of this type of façade.

Summary

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  - Distribution of solar radiation
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